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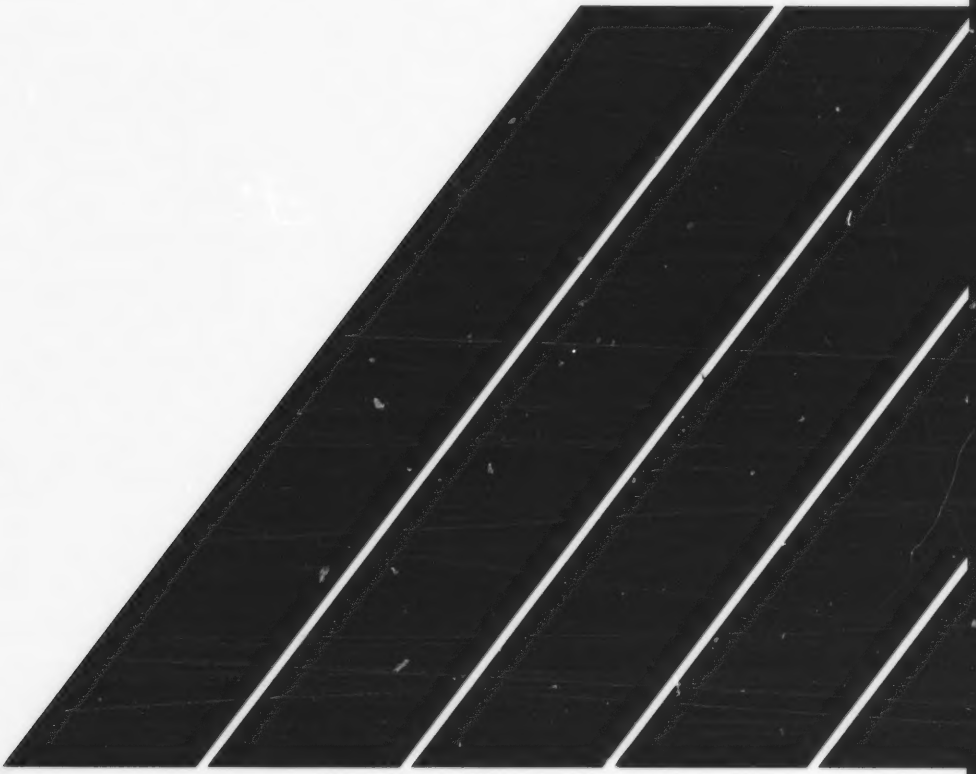

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PRELIMINARY STUDY OF ENERGY PERFORMANCE EVALUATION AND LABELLING REQUIREMENTS FOR WINDOWS

PREPARED FOR:

Efficiency and Alternative Energy Technology Branch
Energy, Mines and Resources Canada
Ottawa, Ont.
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1) Steering Committee Members

- **Chairman** - Paul Loewen - Loewen Windows (representing Canadian Window and Door Manufacturers Association (CWDMA)

- **Industry Members:**

  George Casselman, Alumicor Limited
  T. Duffy, Dashwood Industries
  Frank Fulton, Fulton Windows
  Morgan Hanam, Golden Windows Limited
  Brian Burnet, AFG Glass Inc.
  Leonard Lockhart, Lock-Wood Ltd
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- **User Groups:**

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  Mr. Abichandani, Ontario Ministry of Housing
  Kevin Barrett, Young & Wright Architects
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- **Government & Regulatory:**

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  Tanis Mathers, Canadian Assoc. of Consumers
  Bob Solate, Canadian Home Builders Assoc.

- **Government & Regulatory**:

  Enrico DiNino, Ministry of Energy

  Al Caouette, Canadian Construction Materials Centre (CCMC)

- **Utilities:**

  Gary Pepper, Ontario Hydro

  John Williams, Consumers Gas

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Note: This report has been prepared in SI metric units and any references to costs are stated in 1989 Canadian dollars.

1.4 PREFACE

This report defines the key parameters of an extensive preliminary study related to the energy performance evaluation and labelling requirements for all Canadian windows as defined by input from industry members, user groups and government and regulatory bodies.

The purpose of establishing a voluntary, industry-supported evaluation and labelling program is to encourage window manufacturers to produce high-performance windows in Canada and to provide consumers with an unbiased means of determining performance improvements.

The development of high-performance window technology has advanced significantly but windows that utilize this technology have not yet achieved a large market share.

To counteract this weak market share this project was initiated to:

1. Develop a standard, unbiased procedure for determining the energy performance of windows.

2. Develop a method to present a simple energy performance rating.

This initial study reflects collective opinions to date from project participants.

An effective mechanism to convey the merits of new high-performance window technology, as it evolves, will be in place once the results of this project are implemented by the Canadian window industry.

This report is intended as a basis for discussion by the Canadian Window and Door Manufacturers Association but its contents are also of relevance to consumer groups, utilities and regulatory bodies who have a need to specify or use energy-efficient windows.

For further clarification of some of the calculations and comments presented in this report, please refer to a report titled "Background Information Pertaining to the Preliminary Study of Energy Performance Evaluation and Labelling Requirements for Windows", prepared by ORTECH International for Energy, Mines and Resources Canada dated September 7, 1989.

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1.6 EXECUTIVE SUMMARY

The Canadian window industry is currently facing a challenge. Knowledge and technology related to high-performance windows have developed rapidly, however, the consumer demand for high-performance window products has been impeded because new products cannot be distinguished from conventional products. The window industry needs a simple procedure to inform consumers about the merits of new window technology in a clear, consistent fashion so that consumers can understand the benefits.

Energy, Mines and Resources has calculated that if just half of the windows installed in Canada this year were RSI.7 (R4) instead of RSI.35 (R2) the value of first year energy savings would be 50 million dollars.

Confusion and uncertainty about high-performance windows are a concern to both manufacturers and consumers. This confusion and uncertainty is contributing to the delay in the market response for more energy-efficient windows.

To counteract this confusion this project was initiated for industry to develop a "Preliminary Study of Energy Performance Evaluation and Labelling Requirements for Windows" sold in Canada. The goals are to:

1) Develop a standard, unbiased procedure for determining the energy performance of windows.
2) Develop a method to present a simple energy performance rating.

An unbiased energy performance evaluation of windows is required to support:

1) Building Performance Targets such as those set by R-2000.
2) Utility incentives such as those proposed by Ontario Hydro.
3) Consumers and designer access to performance information.
4) Regulatory compliance (Ontario Energy Efficiency Act, U.S. Legislation).
5) Manufacturer's claims.
6) Comparative shopping for high-performance window products.

More specifically the intent of this project is to:

- Identify energy parameters for evaluating windows and components that relate to CAN/CSA-A440-M84.
- Document the methods for evaluation.
- Consult with the window industry.
- Recommend an energy labelling procedure.
- Recommend a mechanism to administer energy evaluation and labelling.
- Determine the range of costs of the program.

To achieve these objectives the Canadian Window and Door Manufacturers Association (CWDMA) was asked to establish a Steering Group comprised of representatives from industry, user groups and the regulatory boards. The Steering Committee then established three Working Groups who were given specific tasks related to their objective of developing a simple, unbiased energy performance evaluation and labelling procedure.

The committee structure for the project was as follows:

- Steering Committee
  - Chaired by Paul Loewen, Loewen Windows (CWDMA)
  - Industry (nine Manufacturers)
  - Users (CHBA, CGA, CEA, ALTA Housing, RAIC)
  - Government (EMR, OME, CCMC, OBC, US DOE)

- Working Groups:
  - Group A: Evaluation Window Performance
  - Group B: Evaluation of Glazing
  - Group C: Labelling Requirements

ORTECH's key role was to act as the secretariat and be responsible for the overall project co-ordination, technical support, documentation, and reporting. ORTECH International acted as a non-voting member of the Steering Committee.

Through a series of meetings, conversations, written correspondence and technical support, several general issues were reviewed that pertained to the thermal performance labelling of windows. Some of these issues included:

1) Lab Testing vs. Computer Calculation
   - Cost
   - Accuracy
   - Repeatability
   - Credibility
2) Seasonal Performance Ratings
3) How to Label Windows
4) Other Issues:
   - Installed Performance
   - Durability/Aging
   - Optical Properties (Daylighting)
   - Sound Attenuation
   - Condensation Resistance

Extensive input and comment from project participants played a key role throughout the project to define acceptable energy performance evaluation and labelling requirements for windows.

The thermal performance of a window unit is far more complex than a simple R-value. Many factors need to be accounted for, such as,

- Shading coefficient
- Coating emissivity
- Gas fill
- Edge spacer
- Frame
- Weatherstripping
- Orientation
- Building type
- Climate zone

The following factors were deemed as appropriate to define the energy and thermal performance of a complete window unit:

- Air Leakage
- R-Value

- Solar-Optical Properties
- Condensation Resistance (Optional)

This report recommends preferred methods to obtain these energy and thermal factors that have been discussed and essentially resolved. The factors have also been aligned with either the glazing industry or the window manufacturers who will assume responsibility for the generation of the ratings. The source of appropriate R-values has been a very complex issue to resolve and this report states an interim solution that relies on a combined approach of physical testing and computer simulation.

The proposed program to evaluate and label the energy and thermal performance of windows consists of key components that will interact to form the recommended program.

1) Administration Requirements
2) Procedures for Determining Energy and Thermal Performance Values for Windows
3) An Energy Rating Procedure
4) Labelling Requirements

2.1 INTRODUCTION

The Building Performance Group at ORTECH International and the Canadian window industry have combined efforts to establish "Energy Performance Evaluation and Labelling Requirements for Windows". The project was sponsored by Energy Mines and Resources (EMR) with extensive voluntary input from industry members, user groups and government and regulatory bodies.

The project has received direct input from a Steering Committee chaired by the Canadian Window and Door Manufacturers Association. This Steering Committee has helped to resolve several key issues pertaining to an energy labelling program.

As EMR states "Window technology has recently undergone major advances. Low-emissivity coatings, heat-reflecting plastic films, gas fills, non-conductive spacers, and improved frames are already on the market. Other innovative technologies - such as smart windows, ventilation windows and aerogels - are being developed".

Energy, Mines and Resources has calculated that if just half of the windows installed this year in Canada - in the 200,000 new homes, in commercial, institutional and industrial buildings, and in renovations - were R-4, the savings would be an estimated $50 million in the first year alone. If those windows were R-6, the energy savings would be $100 million.

This preliminary study reflects collective opinions from participants in this project with respect to suitable energy performance evaluation and labelling requirements for all windows in Canada. The labelling program will encourage market demand by enabling consumers to purchase high-performance windows with more confidence and insight. Once consumers are able to quantify the benefits of high-performance windows, the energy label will become a useful marketing tool for manufacturers.

2.2 BACKGROUND ISSUES

The Canadian Window Industry is faced with an immediate challenge because the development of high-performance window technology has advanced significantly but windows that utilize this technology have not yet achieved a large market share. The term "high-performance window" according to EMR's definition refers to cost-effective new window designs whose combined optical/thermal/ comfort performance is a substantial improvement over conventional products, (i.e. RSI.7 (R4) or better).

Many of the technological improvements for windows, e.g. low emissivity coatings, gas fills, non-conductive spacers etc., raise issues for both manufacturers and consumers. Questions pertaining to manufacturing technique, quality control, long term durability, cost effectiveness and thermal performance have to be answered.

Manufacturers' thermal performance claims or statements pertaining to energy savings are often based on a variety of test standards and calculations. Theoretical calculations, references to worst case scenarios and environmental differences also accentuate the difficulty in establishing comparative thermal performance ratings.

Windows are not presently tested as a unit to establish the thermal performance and this is also a concern. Currently there are no standards but there are several being developed by groups such as ASTM, ASHRAE and ISO.

Minimum energy performance standards and labelling programs are also under development in the US. where windows have been identified as key components in the energy industry. Once energy labels are in place, the labels could be used in conjunction with incentive programs initiated by the utilities. With the potential for international competition under free trade, it is important that Canadian manufacturers get the technology established quickly in the market place and that the Canadian industry does it in a fashion consistent with US performance claims and labelling. The development of a market for high-performance windows in Canada could ensure that economies of scale are realized and that our industry is in a strong position to trade with the US now that free trade is in place.

From the Canadian window industries perspective there is a need to ensure that the implications on the costs to manufacturers are carefully considered.

It is also important to note that the level of detail required by various consumers also has an impact on the evaluation and labelling requirements. The full list of the thermal performance results in addition to other performance characteristics, would suit the needs of architects, builders, designers and engineers. A method should be devised so that a full test report can be obtained by this professional clientele. However, this information would not be useful to home owners wishing to purchase windows. Therefore, a further streamlining of the parameters should be considered so that comparative selection can be made by the home owner.

Both the Ontario Ministry of Energy and Ontario Hydro have raised very strong points in favour of window energy labelling. By 1990 the Ontario Ministry of Energy needs a program in place to define the thermal performance of windows. Fourteen other products have been regulated to date. Ontario Law will reference Bill 82 and a $10,000 fine will be levied if the products are sold without the correct labels. The Ontario Ministry of Energy will require that a window will not be sold in Ontario without an energy label and they will specify minimum values. The Ministry wants consumers to be able to make an energy based decision and looks to CWDMA to recommend appropriate thermal performance evaluations that tie to the CAN/CSA-A440-M84.

Ontario Hydro has concerns with respect to electric power supply versus demand. They are examining demand versus supply strategy to reduce needs for transmission lines and nuclear stations. Ontario Hydro wants to carry out energy saving programs to offset actual growth in demand. By saving 1 KW with better windows this will translate to $3,000/KW construction cost savings for a new nuclear plant. Ontario Hydro plans to provide cash incentives to put in energy-efficient windows and money is in the budget this year to fund both new construction and renovation projects.

A successful industry-driven program based on consensus is required to encourage the adoption of high-performance windows and foster continuing development of new technologies.

2.3 OBJECTIVES

2.3.1 General Program and Project Objectives

The goals of this "Preliminary Study of Energy Peformance Evaluation and Labelling Requirements for Windows" are to:

1) Develop a standard, unbiased procedure for determining the energy performance of windows.
2) Develop a method to present a simple energy performance rating.

An unbiased energy performance evaluation of windows is required to support:

1) Building Performance Targets such as those set by R-2000.
2) Utility incentives such as those proposed by Ontario Hydro.
3) Consumers and designer access to performance information.
4) Regulatory compliance (Ontario Energy Efficiency Act, U.S. Legislation).
5) Manufacturers claims.
6) Comparative shopping for high-performance window products.

More specifically the intent of this project is to:

- Identify energy parameters for evaluating windows and components that relate to CAN/CSA-A440-M84.
- Document the methods for evaluation.
- Consult with the window industry manufacturers.
- Recommend an energy labelling procedure.
- Recommend a mechanism to administer energy evaluation and labelling.
- Determine the range of costs of the program.

According to Energy Mines and Resources the aim of the project is "To produce a voluntary, industry-supported standardized procedure for measuring the energy performance of windows. The intention is to encourage manufacturer uptake of new energy-saving technologies and to provide consumers with an unbiased means of determining performance improvements by means of a voluntary industry driven program".

2.3.2 Project Criteria

It is important that users have an unbiased means of selecting a quality energy-efficient window. Hence, it is the task of the working groups to define the most appropriate means of providing a user with enough information to make that selection. In order to realize this goal a window evaluation program must satisfy the following criteria:

1) The evaluation procedure must apply to the total window system and must include all of the individual components.

2) The evaluation program must be simple and inexpensive to enable manufacturers to effectively participate in an energy evaluation program.

3) The evaluation procedures must be truly comparative.

4) The evaluation procedures should encompass all potential environmental variables, and indicate the performance in worst case conditions under which a window should be expected to perform.

5) The evaluation procedures must be easily incorporated with the existing window standard in order to prevent confusion and further specification fragmentation and repetition.

6) The evaluation procedures must be applicable to all window products which include gas fills, reflective films and coatings, etc.

In addition it is of prime importance that the working groups consider that any label outlining energy performance will imply a statement of quality. As energy efficiency is only one aspect of product quality, some thought should be given to the other variables associated with window performance. These include, but are not limited to:

- Seal integrity and durability
- Water leakage
- Wind load resistance

- Strength
- Ease of operation
- Component quality
- Material quality
- Durability

It is therefore apparent that it is essential to tie energy labelling efforts to existing recognized window evaluation techniques.

2.4 METHOD / APPROACH

2.4.1 General Overview

To achieve the objectives the Canadian Window and Door Manufacturers Association (CWDMA) was asked to establish a Steering Committee comprised of representatives from industry, user groups and the regulatory boards. Because of international activities in window energy evaluation and to ensure that Canadian Manufacturers have access to the growing international market for energy-efficient windows, a representative of the US Department of Energy was asked to sit on this committee.

The industry-driven Steering Committee and Working Groups, selected by the Steering Committee, reviewed issues in detail, and provided extensive input pertaining to a recommended evaluation and labelling procedure for all types of windows including energy-efficient units.

This initial study reflects collective opinions to date from project participants with respect to a suitable energy performance evaluation and labelling program for all windows made in Canada. Comments were balanced to achieve a general agreement or consensus.

The Steering Committee selected appropriate members from all sectors of the industry to form Working Groups. Three Working Groups, outlined below, were identified . Based on an initial review of the program objectives and the intent of the actual project the Steering Committee established an objective for the three Working Groups:

"The goal or objective of each Working Group is to refine and support a common method to enable industry to present a simple energy performance number to the consumer".

- Working Group A

  Task - To Develop Proposed Methods of Evaluating Window Energy Performance Using CAN/CSA-A440-M84 as the Base.

- Working Group B

  Task - To Develop Proposed Methods of Evaluating Glazing Energy Performance Using CGSB/CAN2-12.8 as the Base.

- Working Group C

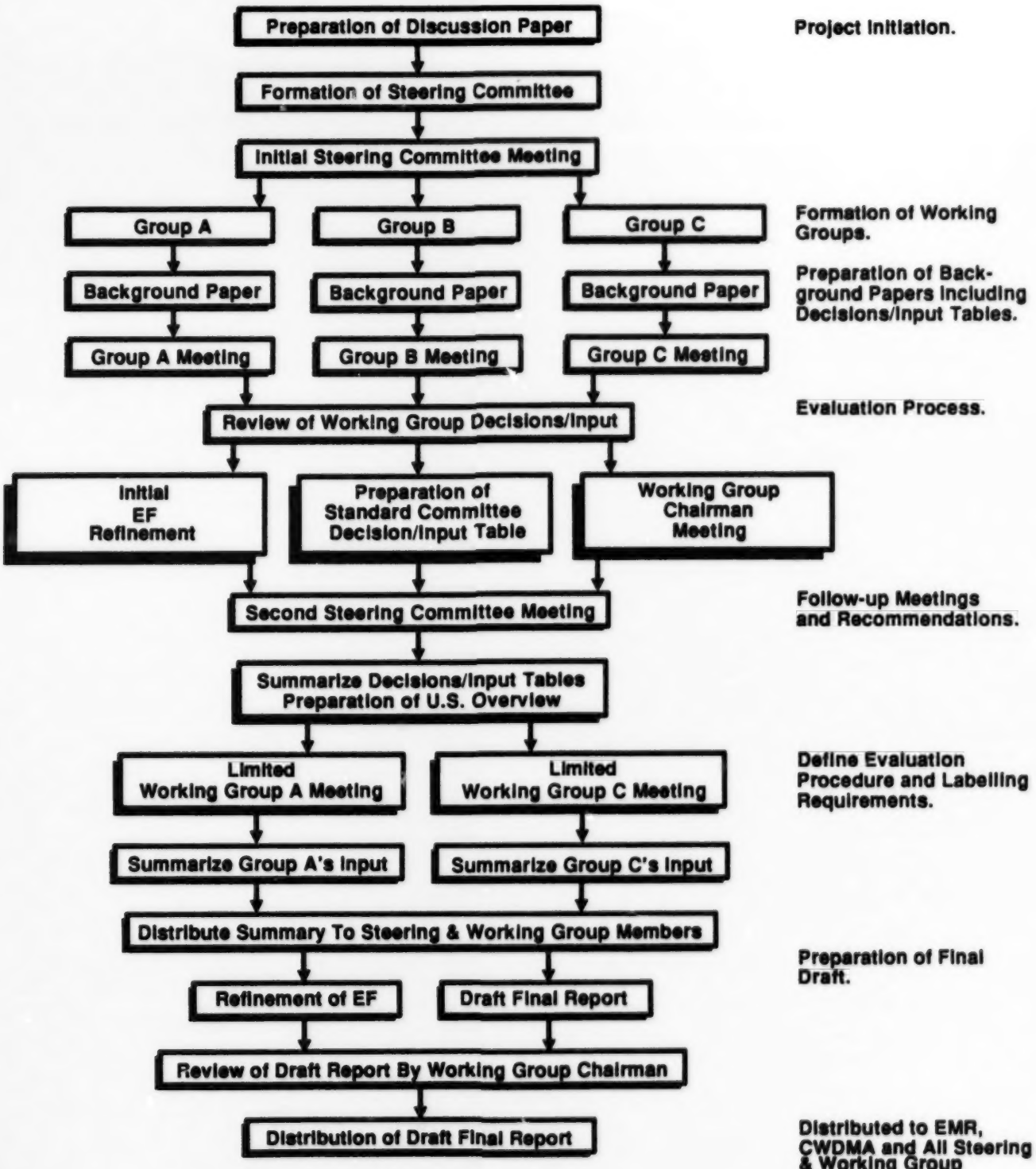
  Task - To Establish Proposed Labelling Requirements.

The working groups provided technical input to the Steering Committee for review. Their mandate was to resolve questions pertaining to the logistics of producing an energy performance evaluation and labelling program.

ORTECH's key role was to act as the secretariat and be responsible for the overall project co-ordination, technical support, documentation and reporting. ORTECH International acted as a non-voting member of the Steering Committee.

The following chart demonstrates the path that this project took in order to fulfill its goals.

2.4.2 Project Sequence Diagram


Preparation of Discussion Paper
Formation of Steering Committee
Initial Steering Committee Meeting
Group A
Group B
Group C
Background Paper
Background Paper
Background Paper
Group A Meeting
Group B Meeting
Group C Meeting
Review of Working Group Decisions/Input
Initial EF Refinement
Preparation of Standard Committee Decision/Input Table
Working Group Chairman Meeting
Second Steering Committee Meeting
Summarize Decisions/Input Tables Preparation of U.S. Overview
Limited Working Group A Meeting
Limited Working Group C Meeting
Summarize Group A's Input
Summarize Group C's Input
Distribute Summary To Steering & Working Group Members
Refinement of EF
Draft Final Report
Review of Draft Report By Working Group Chairman
Distribution of Draft Final Report
Project Initiation.
Formation of Working Groups.
Preparation of Background Papers including Decisions/Input Tables.
Evaluation Process.
Follow-up Meetings and Recommendations.
Define Evaluation Procedure and Labelling Requirements.
Preparation of Final Draft.
Distributed to EMR, CWDMA and All Steering & Working Group Members.

2.4.3 Working Group Mandates

The Steering Committee developed a procedure for each Working Group to define the work that needed to be done. A brief summary of the mandate for each Working Group is as follows:

- Working Group A's Mandate

  Working Group A concentrated its effort on resolving thermal performance issues for the entire window unit. For this reason Group A's activities linked closely with the current window performance standard; CAN/CSA-A440-M84 "Windows".

  The CAN/CSA-A440-M84 provides an ideal starting point for the development of energy evaluation procedures that reflect the performance of the entire window system. The existing air leakage rating, condensation resistance values and potential R-value procedure form the basic core of evaluations that can be used to define the energy performance of complete window units. Currently the A440 recognizes NRC's physical test methods to determine R-value as stated in the Preface.

- Working Group B's Mandate

  Working Group B concentrated its effort on resolving energy and thermal performance issues for the sealed glazing unit only. For this reason Group B's activities linked closely with the current insulating glass standard, CGSB/CAN2-12.8.

  The CGSB/CAN2-12.8 provides a good starting point for determining the seal integrity of the unit but it does not address the energy performance issues. The existing ASTM, PGMC and CGSB standards were good starting points for this group.

- Working Group C's Mandate

  Working Group C concentrated its effort on establishing an effective means to display energy and thermal performance ratings for the entire window unit.

  Simple energy performance numbers were developed by Working Group A and B. Therefore Group C's responsibilities included establishing the

- Label Design
- Strategic Plan for Administration of the Label
- Strategic Plan for Promotion of the Label and its Contents

Each Working Group faced the challenge that the data generated from present window evaluations is not presently listed in a format that is clearly evident to the average consumer. Due to the variety of numerical units and evaluation techniques it is also not possible to combine the ratings to one common number that defines the energy and thermal performance of the window and the glazing options.

Ultimately it is anticipated that the energy and thermal performance number or the evaluation procedure can be referenced by appropriate industry standards so that industry members who wish to produce an energy label for their products can do so within the existing framework of product evaluation.

2.5 TECHNICAL INPUT/SUPPORT

2.5.1 Overview of Key Issues

Both the Steering Committee and Working Groups identified several key issues that pertained to the energy and thermal performance labelling and evaluation of windows. Some of the key areas of debate and input are based on the following issues:

1) Lab Testing vs. Computer Calculation
   - Cost
   - Accuracy
   - Repeatability
   - Credibility
2) Seasonal Performance Ratings
3) How to Label Windows
4) Other Issues:
   - Installed performance
   - Durability/aging

- Optical properties (daylighting)
- Sound attenuation
- Condensation resistance

2.5.2 International Review of Standards

To ensure that existing energy evaluation techniques for window and glazing systems were not overlooked, an international review of standards was conducted.

Industry generally defines the thermal performance of glazing and complete window units according to the following variables:

- U-Value = Thermal Transmittance
- U-Value Seasonal = Adjusted Thermal Transmittance
- R-Value = Thermal Resistance
- R-Value Seasonal = Adjusted Thermal Resistance
- Heat Gain = Total Heat Admission Through Glazing
- Transmittance = Transmitted Solar Radiation
- Reflectance = Reflected Solar Radiation
- Shading Coefficient = Unique Fenestration Characteristic
- Air Leakage = Air Infiltration Rate
- Condensation Resistance = Performance Parameter
- K-Value = Thermal Conductivity

Further review shows that these variables are determined using one or more of the following techniques.

1) Empirical Calculations:
Thermal performance calculations based on the correlation of fundamental heat transfer theory and accepted experimental data under a set of defined conditions.

2) Physical Testing:
Physical determination of thermal performance by direct measurement under a set of defined conditions.

3) Computer Modelling:
Empirical determination of thermal performance based on heat transfer theory, experimental data and automated analytical computation techniques under a set of defined conditions.

A summary of the methods currently used to determine the energy performance variables identified, has been provided in the Background Information Report associated with this document.

2.5.3 Selection of Energy Evaluation Factors that Potentially Identify Window Systems

The following thermal factors have been identified to define the energy performance of a complete window unit.

- Air Leakage
- R-Value
- Solar-Optical Properties

Air leakage was deemed to be appropriate by the entire group. It was defined as an important factor.

R-value was also deemed as an appropriate factor to define the thermal performance of a window. Some manufacturers suggested that the R-values provided by the glazing suppliers were adequate for many clients. The industry clearly supports R-value as a recognizable way to define thermal performance to users but they do not want to see existing window test programs expanded to include additional testing due to the extra costs. The selection of appropriate R-value data is a complex issue in that presently window manufacturers' customers are not asking for precise R-values.

Solar-Optical Properties were generally favoured as being important factors but they are not clearly understood by most window manufacturers.

Input from academic research groups has helped to clarify the impact of solar optical properties on window performance and window manufacturers have agreed to rely on the data provided by the glass manufacturers.

In addition to air leakage, R-value and solar-optical properties other factors were also reviewed that potentially link to the thermal performance of a window. Condensation resistance, long term durability combined with pay-back, sound attenuation and installation techniques were raised as side issues that need to be addressed but they were not directly defined as energy factors to be included in the label.

Energy evaluation and labelling implies ranking therefore it should include other performance issues. Consumers require more information about a window than just energy performance, therefore the energy labelling should be tied to existing window product evaluation and testing standards.

2.5.4 Preferred Method to Obtain Energy Factors

- Air Leakage
  A physical test is clearly recommended. The evaluation procedure defined in CAN/CSA--A440-M84 is recommended for Canada. Alignment with US procedures has been expressed as a concern.

- R-Value
  The long term goal of both industry and regulatory bodies is clear - evaluate the complete window R-value using computer modelling. However, at this point in time the computer models' ability to predict the R-value of a complete window system accurately enough to account for variations in the frame construction is under review. This is particularly true if the frame is a composite or has a complex cross-section. There is a need to establish how close computer model calculations are to laboratory test results and this issue is currently being addressed in a joint Canada-US research program. Until computer programs accurately reflect subtle frame variations the following interim evaluation process reflects the scientific communities opinions to date. A combined approach that includes both physical testing and computer modelling is deemed appropriate. Since the Draft ASTM method appears to be well accepted in the US, it may be appropriate to combine this method with a computer evaluation. Technical competence is critical and continuing research and technical support activity is required to ensure that credible procedures are developed.

A proposed solution by the scientific community would be to evaluate one profile line in accordance with the draft ASTM procedure. The draft procedure for window U-value testing (ASTM 1988) will merge the requirements of four different procedures, namely:

1) AAMA Hot Box Method
2) ASTM C-236 Guarded Hot Box
3) ASTM 976 Calibrated Hot Box
4) National Research Council of Canada's Hot Box (Bowen 1985).

Other products from the same manufacturer with the same profile could then be evaluated using a validated computer model, modified with actual frame/glass performance factors determined from the initial lab test. Ultimately it is anticipated that the A440 will reference this evaluation procedure.

Beyond this recommendation there are several outstanding issues that need to be resolved. Window manufacturers have expressed concern that the information provided by R-value physical testing as a comparative value may show insignificant differences between products of like materials at a prohibitive cost.

Computer simulated "R" values are the chosen direction but in its current state simulated values have not been proven to duplicate lab testing results for some materials and complicated shapes.

Priority must be given to develop validated computer modelling to ensure that a computer can duplicate all window designs as lab tested. It is critical that computer models use correct input thermal data for various glazing and window frame components.

The R-value issue is a significant indeterminate at this time since it may largely dictate when any kind of energy labelling program might be feasible in terms of time frame. It also impinges on what testing costs may be involved and indeed the sensitivity of results could dictate the credibility of any labelling.

- Solar-Optical Properties

  Empirical calculations, computer modelling or look-up tables are supported to obtain these factors. The window manufacturers feel that it is primarily the responsibility of the glazing manufacturer to produce this data. The Insulated Glass Manufacturers Association of Canada (IGMAC) has stated "IGMAC will support the supply of optical and thermal values by member manufacturers to window manufacturers as required, based on data available from glass manufacturers, referencing the glass actually used to manufacture sealed units". The testing laboratory would then calculate the shading coefficient by running approved computer programs. For glazing units with interior blinds or decorative grills, the window manufacturer would be responsible for shading coefficient testing.

A new standard is required to incorporate new glazing technologies and their relative impact on seal integrity and thermal performance.

The ASTM is currently considering a proposed standard of measuring glazing emissivity (PGMC 1988), which the glass industry has agreed to follow voluntarily until approved by the ASTM.

2.5.5 Industry Sector Responsible for Energy Factors

This issue was debated to help align the energy evaluations with either the glazing industry or the window manufacturers. General consensus suggests that:

- Air Leakage is the responsibility of the window manufacturers.
- R-Value is an even split between the glazing industry and the window manufacturers. This is due to the variations in the level of accuracy required and the anticipated costs associated with testing the complete window unit.
- Solar-Optical properties are identified as the responsibility of the glazing industry.

2.5.6 Preferred Method to Reference Energy Evaluation Procedures

The energy evaluations should be referenced by appropriate existing industry standards that include, CAN/CSA-A440-M84, CGSB/CAN2-12.8, CGSB/CAN2-12.4 and CGSB/CAN2-12.10. Industry feels that the energy evaluation and labelling requirements should be covered by a recognized procedure - not a new standard.

2.5.7 The Proposed Energy Efficiency Rating (E_R)

As stated in section 2.5.3 "Selection of Thermal Factors that Potentially Identify Window Systems" the concept of a single R-value number, already familiar to consumers, was judged to be too simplistic because it could not include solar gains or air leakages, and thus would not allow consumers to differentiate between products with similar U-values but different shading coefficients or weatherstripping

After extensive discussion and technical review both the Steering Committee and the Working Groups strongly support a number that combines several energy performance values into a single dimensional number. The energy efficiency rating or E_R number could be used to denote thermal efficiency of the complete window unit. The E_R number or energy balance calculation is expressed in watts per square meter of window and can be simply defined as:

E_R = Solar Gains - Heat Losses/Gains - Air Leakage

Mathematically, the formula becomes:

$$E_R = [0.87 \cdot SC \cdot F_I \cdot H_t] - [(T_{bg}-T_a) \cdot U] - [(T_{bg}-T_a)\, L_{75} \cdot P_f \cdot \sigma C_p)/20A_w]$$

Where:
- E_R is the effective energy efficiency rating, W / m^2.
- SC is the shading coefficient of the total window at normal incidence, dimensionless.
- F_I is the off angle incidence factor.
- H_t is the average solar radiation over the heating season (averaged over 4 orientations), W / m^2.
- T_{bg} is the average indoor building temperature over the heating season, °C. Taken as 20 °C.
- T_a is the average outdoor temperature over the heating season, °C.
- U is the thermal transmittance of the total window, W / $m^2 \cdot$°C.
- L_{75} is the average air leakage of the window, L/s, at the 75 Pa test pressure difference.
- P_f is the pressure factor relating to the combined wind and stack effect pressure differentials acting on the window.
- σC_p is the heat capacitance of air at standard conditions. 1.2 kJ / $m^3 \cdot$ °C.
- A_w is the total area of the window, m^2.
- 20 is the air leakage factor relating measured window leakage to average calculation leakage.

With this form of the equation E_R may be a positive or negative value representing the net energy gains or losses of a window under a specified set of climatological conditions.

This equation is very sensitive to fluctuations in climatological conditions such as :

- indoor and outdoor temperature (T_{bg}, T_a)
- incident solar radiation (H_t)
- pressure factor (P_f)

To ensure that the rating will enable comparison of products across Canada standard heating climate conditions have been used. Analysis was carried out by Enermodal Engineering using a computer modelling technique (Enerpass) based on a "Typical House" and weather data provided by the University of Waterloo. The weather values for 13 cities with heating-dominated climates in the 4,000-6,200 degree-day range, were averaged to produce a single set of "average heating "climate weather conditions:

$H_t \times F_i = 72.2\ W/m^2$
$T_a - T_{bg} = 21.9\ C$
$P_f = 1.5$

The "Typical House" is 200 M^2 with 15% window to floor area, equally distributed. The pressure factor P_f combining wind and stack effects is from ASHRAE Fundamentals 1985. Work is continuing on addressing the cooling in residential buildings and whether the rating should be extended to include commercial buildings.

Initial sample calculations of the E_R rating based on available lab data indicates that the E_R values will range from roughly a net loss of 26 W/sq.m for a standard double glazed window to a net loss of 9 W/sq.m for a tight high performance unit (i.e. triple glazed, 2 low-e, gas filled or triple glazed heat mirror). Based on calculations for the Toronto, Ontario area average window heating season energy costs would range from $7.00/sq.m for a standard double glazed unit to a low of $3.00/sq.m for a similar high performance unit.

2.5.8 Thermal Factors That Could Complement Energy Evaluation Factors

Several other thermal factors that do not specifically relate to the energy loss of a window but help to define the performance of a complete window were reviewed and should be considered as an option.

Condensation resistance rating appears to be a good way to define the actual thermal performance of a complete window, in that it will reveal the thermal performance of the glazing and the frame. It can also be used to help align a geographical location with a specific window product. Some concerns were expressed that condensation resistance testing would be an extra cost for the wood and vinyl manufacturers. Some manufacturers felt that this rating had the potential of doing more harm than good if home owners did not clearly understand the rating. Some cautions were also raised that Canadian values will not align with US procedures. The US currently favours condensation resistance ratings due to health concerns and wants to see it on US labels.

The working groups defined a preferred method to obtain condensation resistance.

A physical test is currently recommended for this rating as other calculation methods are not available. The revised evaluation procedure defined in CAN/CSA-A440-M84 is recommended for Canada, although alignment with US procedures has been expressed as a possible concern. Work is underway to determine the feasibility of calculating the condensation resistance through computer modelling or infrared thermography analysis.

The industry sector that will likely assume responsibility for determining the condensation resistance will be the window manufacturers due to the impact of the window frame.

2.6 Proposed Energy and Thermal Performance Evaluation and Labelling Requirements and Administration

The Working Groups have defined an initial energy evaluation and labelling program for all windows. It consists of four major components that interact to form the recommended program;

1) Format and Content of the Label
2) Program Administration
3) On-Going Quality Control
4) Education, Marketing and Training

Each component of the program and the approach defined by industry consensus is outlined in the following sections.

The proposed implementation process and associated costs are also outlined in section 2.6.5.

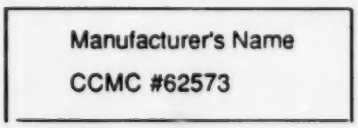
2.6.1 Format and Content of The Label

The Working Groups have suggested two labels for all windows in Canada - a permanent one and a temporary one. The data contained in the labels will link with the administration program and the CAN/CSA-A440-M84 performance evaluations. Ultimately the design and application of the label should be defined by a professional marketing firm.

2.6.1.1 The Permanent Label

The permanent label should be a small, embossed label mounted with a permanent adhesive at the top centre inside surface of the window frame. The label's contents will be restricted to the manufacturer's name, administration body (CCMC) and the product serial number or CCMC number.

The permanent label design should resemble the following sketch:



The manufacturer's name and the CCMC # or the CCMC # alone would enable a consumer to permanently have access to information on file at CCMC such as:

Manufacturer's Name
Window Description and Options
Performance Test Results
Test Methods Used) Due to the constant changes in the window industry
Date of Manufacture) such as new products, materials, etc., it is important
) to develop a system that allows for revision.

This data will be retained by CCMC on file and will be published in a CCMC document, distributed nationally that will list window products with a current CCMC #.

2.6.1.2 The Temporary Label(s)

The temporary label(s) will be comprised of a core section that represents the CAN/CSA-A440-M84 performance data and an optional section that will highlight the thermal performance data. The temporary label(s) should be large and colourful mounted with a temporary adhesive anywhere on the interior glass surface. The label's contents will include the manufacturer's name, administration body (CCMC), the product serial number and specific performance data related to CAN/CSA-A440-M84 and the thermal performance. The label design should resemble the following sketch:

Energy Efficiency Rating	Manufacturer's Name CCMC #62573
E_R # X Watts/m2	Air Leakage Water Leakage Wind Load Resistance Strength and Stiffness Ease of Operation
Additional Thermal Performance Data	
• Solar Optical Properties Thermal Resistance Condensation Resistance (Optional)	

⇐ A440 Data

E_R # may display a value

for: Heating Only
Heating and Cooling
Cooling Only

Further work is underway to present this information.

For simplicity of marketing and consumer awareness the label could be produced in different colours. To obtain a colour coding the manufacturer must complete all sections of the label.

Utilities would like to advise buyers to buy a Gold, Silver or Bronze product. For example, in a Maritime application the utility or window specifier may state, "Buy a bronze window but ensure that it has a gold rating in air and water". The window manufacturers have raised concern that this is an over-simplification that does not address water leakage and wind loading required in the same geographical area.

All of the data contained on the temporary label(s) will be retained in CCMC's files and publications for future reference once the temporary labels are removed. CCMC is willing to allocate space in their publication to flag thermal performance issues if CWDMA deems it appropriate for the industry and consumers.

2.6.2 Program Administration

Industry clearly supports the Canadian Construction Materials Centre (CCMC) as the recommended administration body. CCMC currently has roughly 500 Canada Mortgage and Housing Corporation (CMHC) window reports on hand that will be updated to a National CCMC document in 1989. Industry has recommended that the program have both a core and an optional method as defined below.

Core: CCMC # obtained when the basic CAN/CSA-A440-M84 performance data is available and the product is listed in CCMC publication.

Option: All of above plus complete thermal data.

CCMC has briefly outlined their administration plan in a letter to ORTECH dated February 9, 1989. CCMC's voluntary program is based on the CAN/CSA-A440-M84 standard with input from the Canadian Window and Door Manufacturers Association and has full Provincial and Territorial support.

2.6.3 On-Going Quality Control

CCMC has defined a voluntary window evaluation and energy labelling procedure that will could substantiate and define window performance but it is clearly not intended to be a certification process.

Key components of the on-going quality control process are that:

1) All CAN/CSA-A440-M84 and thermal evaluations will be conducted by a CCMC approved laboratory.

2) CCMC has requested that window sampling take place on a random in-plant basis. Prototypes will not be evaluated. Manufacturers will challenge this and look for an acceptable alternative. One manufacturer has suggested that it would be more appropriate to have the manufacturing method inspected to determine compliance.

3) CCMC will require a document of check points from manufacturers that defines in-house quality control.

4) CCMC will review the quality control process, log books etc., but will not conduct actual plant inspections. Since the plant quality control will be administered by the manufacturer and reviewed by CCMC this evaluation system is not a certification process.

This type of on-going quality control process has been applied successfully to numerous other construction materials and systems.

It is unclear whether this or alternative methods will be employed. Strategies for self-policing have been suggested as alternatives. One example, the challenge system would rely on industry challenging others in the market if unfair product representation was suspected.

2.6.4 Education, Marketing and Training

Working Group C has defined that appropriate promotional activities for the following market sectors would be:

For: Building Code Officials

Use: Seminars, newsletters, magazine articles and direct correspondence through the Ministry of Housing.

For: Construction Professionals

Use: As above, plus association newsletters and seminars, articles in trade journals and liaison with Home Warranty programs.

For: General Consumers (Residential)

Use: Press release, article in Canadian Consumer Magazine and utility bill stuffers. Canadian Consumer Magazine article would be retained by public libraries for future reference. Point of sale information pamphlets would also be helpful.

For: International Markets

Use: International Standards Organization (ISO) and North American window and glass trade association newsletters.

For: Owners/Property Managers

Use: Builders Owner Managers Association (BOMA) newsletters and seminars, CMHC and Canadian Home Builders Association (CHBA) and relevant trade journals.

For: Utilities

Use: Canadian Electrical Association (CEA) and Canadian Gas Association (CGA).

For: Window Industry

Use: Canadian Window and Door Manufacturers Association (CWDMA) and Insulated Glass Manufacturers Assoc. of Canada (IGMAC) plus articles in Canadian and US glass magazines such as Alumi-News, Glass Canada, etc.

These promotional activities or contact points were defined largely by Working Group C who ultimately recommended that a professional marketing firm be hired to promote the energy labelling program. This approach combined with a simple energy rating system that can be

quickly understood by consumers of all levels will ensure that the concept is professionally delivered to the market.

2.6.5 Proposed Implementation Process and Associated Range of Costs

The proposed process or steps necessary for a window manufacturer to obtain an energy rating label and the approximate costs per window type would be as follows:

1) Ensure that the sealed unit meets the CGSB/CAN2-12.8 standard for insulating glass units.
   Cost: $1,720.00
   Note: This evaluation is the responsibility of the sealed unit supplier.

2) Obtain the glass optical properties from glass supplier.
   Cost: Nil

3) Submit the complete window unit to a CCMC approved laboratory for testing in accordance with the CAN/CSA-A440-M84 Window Performance tests.
   Cost: Wood - $1,200-1,400*
   Aluminum - $3,100 - 3,300
   Vinyl - $1,200-1,600*
   * **Note**: The aluminum testing price includes condensation resistance testing. An additional $1,500-2,000 would apply to the wood and vinyl windows to obtain this condensation rating if required. This assumes that physical testing is used. A calculation method would virtually eliminate any added costs.

4) Obtain R-value or U-value for complete window unit from a CCMC approved laboratory.
   Cost: Computer Calc. - $200-300
   Physical Test - $3,000.

5) Based on data obtained during steps 2, 3 and 4 contact a CCMC approved laboratory to calculate the E_R value.
   Cost: $100.

6) Send all data to CCMC and apply for a CCMC #
   Cost: $100 annual listing fee.

If a manufacturer currently uses approved sealed glass units and has the finished window units tested in accordance with the CAN/CSA-A440-M84 the additional costs associated with providing an energy label would be:

Aluminum Windows:	$350 to 3,200.00
Wood Windows:	$350 to 4,950.00
Vinyl Windows:	$350 to 4,950.00

This assumes that all energy testing is requested. The low and high prices are related to the differences between computer calculations and physical tests.

2.7 DISCUSSION

There are 3 inter-related industry sectors that are involved in the flow of new energy improved high-performance windows to market. The following three sectors constitute the window industry:

- Manufacturers
- Regulatory Bodies
- Consumers

Once the correct evaluation procedures are established by the window industry, any manufacturer will know the standards of comparison. The regulatory bodies will then be able to evaluate similar products. Finally, the consumer will be able to compare the results. Awareness of a product's performance and an ability to comparison shop will create a market demand for good products, and this awareness will also allow manufacturers to obtain product recognition for their improved products.

The dynamics of both the window industry and the standards of evaluation combined with the increasing activity of international trade provide the basic challenges for a successful energy labelling and evaluation program. The proposed labelling program fits the requirements of a changing window industry.

The nature of the evaluation program needs to be kept open enough to accommodate improved evaluation techniques but it should not be left completely open to interpretation.

The Department of Energy (DOE) and EMR have now entered into a co-funding arrangement to resolve appropriate test procedures. Product import and export will be greatly simplified and duplication of testing can be reduced if we align our program with the US. However, Canadian test procedures will need to be substantiated and accepted throughout the US. New physical tests such as the evaluation method currently being developed by Dubrous and Harrison at the National Solar Test Facility in Mississauga and computer programs such as VISION and FRAME will need to compete directly with accepted US procedures. The cost of selling Canadian procedures to the US and the time involved should not be underestimated. If US liaison is a key requirement to develop co-operative projects between DOE and EMR the current thrusts of some Canadian research needs to be ready for major additional expenses to gain acceptance in the US. Industry clearly wants to minimize the number of evaluation techniques and this could put further pressure on selecting appropriate test procedures.

Concerns pertaining to the legal implications of energy labelling have also been raised. If a product is selected based on its thermal performance and the computer program or physical test predicts an R-value etc. that favours the wrong product a lost sale may result. The company or government agency that developed the evaluation technique may be required to validate the data in a legal debate. This type of concern tends to suggest that very accurate, universally accepted, evaluation techniques will be preferred by industry.

Some manufacturers have suggested that energy labelling could eventually lead to certification. The intent of this project from the start has been to provide standardized energy performance information not certification. The recommended administration group Canadian Construction Materials Centre (CCMC) with input from CWDMA will initiate a quality control program to be administered by the manufacturers, and reviewed by CCMC.

The source of appropriate evaluation techniques relates to selecting appropriate empirical calculations, physical testing, or computer modelling that satisfies needs in both Canada and the US.

Numerous players have had a direct influence on defining the needs for the window energy evaluation and labelli:.g program. The broad exposure gained through the members of the Steering Committee and Working Groups has tended to complicate issues at times but in the long run a program that takes into account a broad array of factors has been developed by industry. It is anticipated that by taking all of these factors into account as the program developed the recommended program should be positioned well for long-term success in both Canada and the United States.

3.0 FINAL SECTION

3.1 Conclusions/Recommendations

As mentioned throughout the text of this report, some issues are still unresolved at this point in time. They are primarily related to test/calculation methods. The current Canada/US research project is focusing on the following issues:

- Validation of calculation procedures (Vision/Window, Ansys/Frame)
- Correlation of calculation procedures with field tests (MoWiTT) and lab tests (AAMA, ASTM C-236, ASTM 976, NRC Hot Box and PGMC 1988).
- Design tools and information for the building industry.
- Procedures for evaluating the long-term performance.
- Seasonal Energy Rating Factors

The key input required for this energy evaluation and labelling task is the identification of a suitable physical and computer method to define window R or U-values.

The Canadian Window Industry faces a unique challenge in designing and implementing a window energy evaluation and labelling procedure. The Working Groups have recommended that to successfully implement the program in the marketplace the Canadian Window and Door Manufacturers Association (CWDMA) should:

1) Present the program to a broad array of CWDMA members for their review and comment Both the A440 and IGMAC technical committees should also have an opportunity to review the procedure to ensure that both committees buy-in to the procedure and reference it in the appropriate standards and the new building code.

2) Meet with the Ontario Ministry of Energy. They have an immediate need to implement a window energy labelling program and their requirements for a reference document should be clearly understood.

3) Review the proposed administration program with CCMC. They will require input with respect to the format of their document to list products with CCMC numbers.

4) Identify a professional marketing firm with the assistance of Ontario Hydro to ensure that the program is designed with the same success as the appliance "Energuide" numbers.

5) Approach Canadian Standards Association (CSA) to formally write the energy labelling and evaluation procedure that could be referenced by the CAN/CSA-A440-M84, CGSB/CAN2-12.8 and other appropriate standards.

6) Present the evaluation and labelling procedure to the appropriate ISO committee and State Building Code Officials. Through active participation at the ISO level it is anticipated that the Canadian energy labelling activities will harmonize with the activities of other countries.

7) Define the extent of overlap required with US evaluation and labelling programs. A great deal of time and money will be needed to support Canadian evaluation techniques in the US to gain full acceptance.

To develop the concept further and implement a technically competent system in the Canadian marketplace, the following key activities will need to take place.

- Development of standardized test/calculation procedures (joint US-Canada project)
- Incorporation of energy performance evaluation procedures in CAN/CSA-A440-M84 window standard.

- Development of sealed glazing unit test standard for high performance windows.
- Implementation of a labelling program through Canadian Construction Materials Centre (CCMC).

Due to the nature of the window industry and the constant development of new products and evaluation techniques, it will be necessary to ensure that the evaluation and labelling program is kept open and reviewed annually. By establishing a basis of comparison for window products the merits associated with high-performance window units will become apparent and consumers will be able to make an educated selection. The acceptance of high-performance windows will help to create a market for the units in Canada and the need to further improve window products will be established in a competitive industry environment.

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